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DEFINING THE FUTURE

Expanding Statistical Process Control Across All Engineering Disciplines

A Sequence of Practical Case Studies

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- **Purpose**
  - What you will see
- **SPC principles**
- **Prior presentations**
  - 2005 ï Log-cost model for controlling software code inspections
  - 2006 ï Statistical Process Control early in the system/software life cycle
- **Case studies from other disciplines**
  - Test
  - Avionics
  - Vehicle
  - Logistics
- **Summary**

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- **Illustrate a variety of statistical process control (SPC) applications with realistic engineering case studies**
  - Multiple engineering disciplines
    - Software, hardware, logistics
  - Process improvements applied to selected processes when it makes sense for the business
- **Portray operations of a large organization that has been at Level 5 for 2 1/2 years**
- **Suggest a potential range of SPC applications beyond software**

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Will See

- **Lots of control charts**
- **But that's not the point – you should focus on**
  - Broad applicability of SPC techniques to all engineering disciplines
  - Major business themes that emerge
    - Cost
    - Schedule
    - Quality
  - Vast majority of optimizing process improvements are simple in nature
    - But so is rocket science, *that's why it works*
- **Occasional out-of-control points**
  - All examples were taken from ñliveò project data
    - Special causes of variation do occur, thatôs why we use SPC to manage projects

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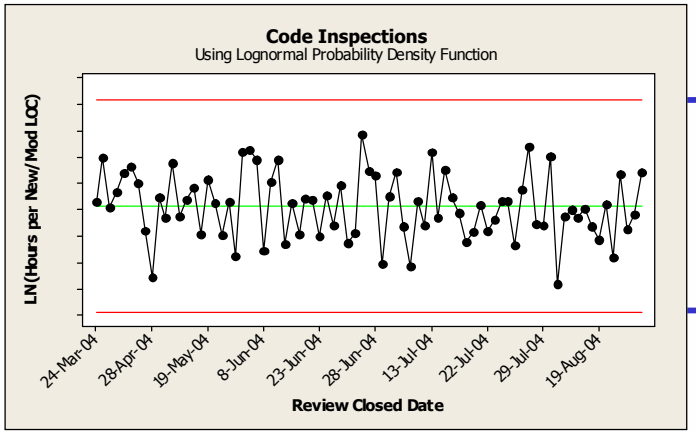
Principles

Listening to the Voice of the Process



Upper Control Limit

Average performance

Lower Control Limit

A stable process operates within the control limits 99.7% of the time

Analysis of

- **Special cause variation** focuses on recognizing & preventing deviations from this pattern
  - Offers superior project management results
- **Common cause variation** focuses on improving the average and tightening the control limits
  - Offers opportunities for systematic process improvement that company & industry benchmarks indicate yields a return on investment averaging between 4:1 & 6:1

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Process Selection

- **Statistical control is imposed on sub-processes at an elemental level in the process architecture**
- **Processes are selected based on their**
  - Statistical suitability ï ñnecessary conditionsò
  - Business significance ï ñsufficient conditionsò
- **Business checklist**
  - Is the candidate sub-process a component of a projectôs defined ñkeyòprocess?
    - Is it significant to success of a business plan goal?
    - Is it a significant contributor to an important estimating metric in the discipline?
  - Is there an identified business need for predictable performance as projects execute the subprocess?
    - Cost, schedule or quality
  - Is there risk if subprocess variation is not understood or controlled?

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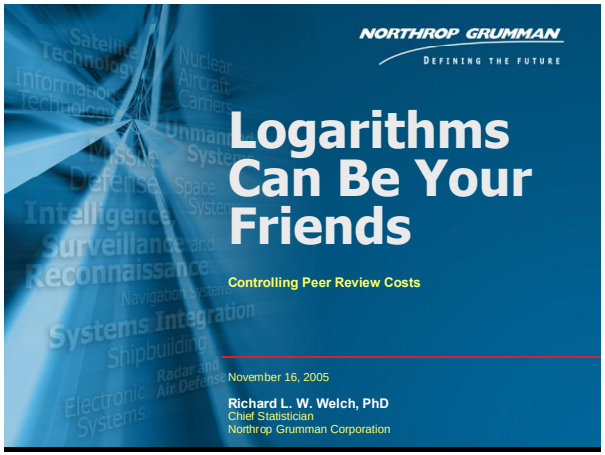
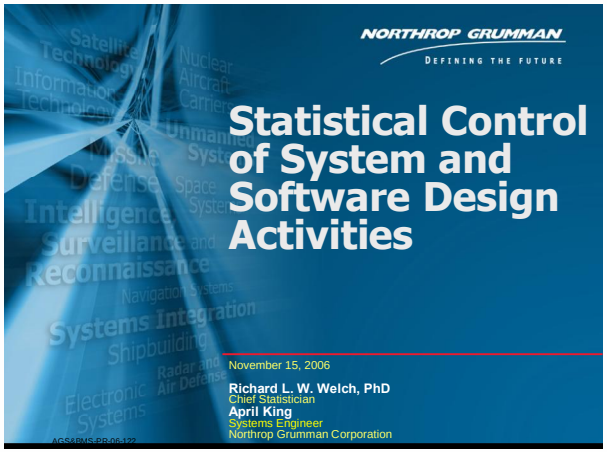
ntations

- **2005 – Author demonstrated applicability of a log-cost model to control software code inspections**
- **2006 – Author demonstrated how to use the log-cost model to control peer reviews early in the system/software life cycle**
  - ñOutstanding Presentation for High Maturityò
  - ñConference Winnerò





Note: Prior CMMI Technology Conference & User Group papers are published on-line at: http://www.dtic.mil/ndia/

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Statistically Managed Processes

Covered in the Prior Presentations

- **System Engineering**
  - System design & system architecture peer reviews of
    - System threads
    - System model (structure diagrams)
    - Physical model
    - UML diagrams
  - System & software requirements peer reviews of
    - Proposed specification changes
- **Software Engineering**
  - Software design peer reviews of
    - Software threads
    - Physical model
    - Component/task descriptions
    - Data model
  - Software code inspections
- **Test & Engineering**
  - Peer reviews of test plans, procedures & reports

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Statistically Managed Processes

Other Engineering Baselines

- **System Engineering**
  - System product errors
- **Software Engineering**
  - Software build process
  - Software build returns
  - Software test returns
- **Test & Engineering**
  - *System Integration Lab (SIL) scheduling*
  - *Flight Test Card development*
- **Vehicle Engineering**
  - Electro-mechanical drawing errors
  - *Vehicle subsystems (i.e., crew & equipment) drawing errors*
- **Avionics**
  - *Discrepancy Inspection Report (DIR) processing*
  - Avionics Drawing Sign-off
  - *Field Service Engineering Request (FSER) processing*
  - Management of seller issues
- **Logistics**
  - *Air Force Tech Order (AFTO) processing of the*
    - *Total contractor schedule*
    - LSA group schedule
  - *Integrated electronic technical manual (IETM) delivered quality*

Baselines span all life cycle phases & disciplines

Note: baselines highlighted in italics are featured in this presentation.

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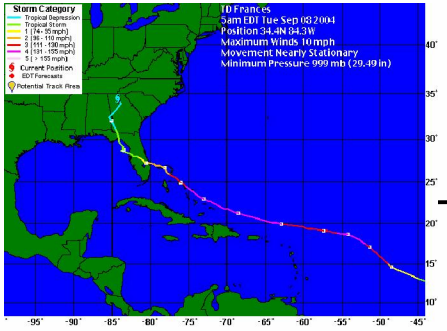
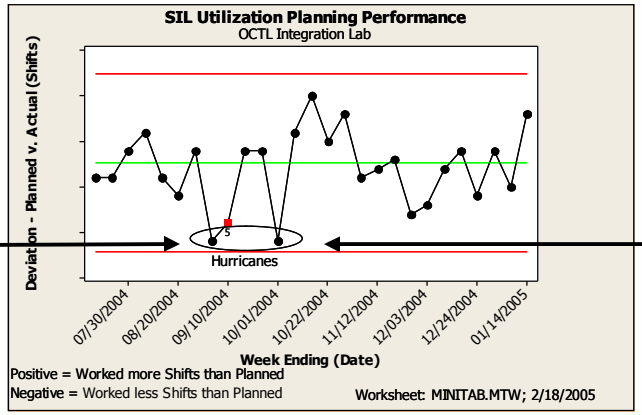
Test & Evaluation

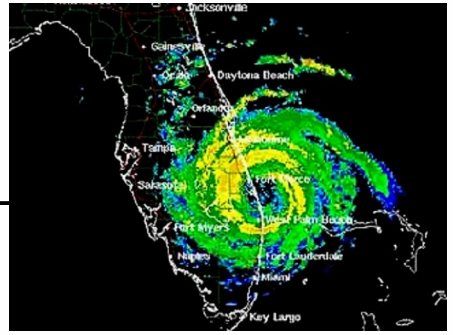
System Integration Lab Scheduling
Flight Test Card Preparation

luation

- **An early 2005 analysis determined that improved System Integration Lab (SIL) resource utilization could provide significant cost savings**
  - Scheduled shifts not worked waste Lab Ops resources
  - Unplanned, late requests for lab support induce overtime expenses
- **Statistical analysis of past year's data revealed the process was stable (with two unusual exceptions)**







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tion Scheduling

Process Overview

Process Title Lab Utilization Scheduling

Process Definition Provides deconflicted and effective Lab utilization by various projects.

Input

Varied Integrated Product Team (IPT) Requirements

Sub-Processes Steps

- IPT Rep Identifies Requirements
- Next Months Baseline Established
- Weekly Schedules Developed & Posted
- Weekly Schedules Marked to Reflect Actuals
- Planned (Monthly Baseline) Versus Actual Metric Created

Output

- Long Range Schedule
- Next Month Baseline
- Weekly Schedules
- Planned Versus Actual Metric

Applicable Procedures

- Long Range Lab Utilization Scheduling
- Weekly Lab Scheduling

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ent Focus

- **Training**
  - Re-affirmed the need for accurate planning
  - Revised lab planning procedures disseminated widely
- **Tools**
  - Planned vs. Actual utilization spreadsheet ï tracks the lab utilization deviations
- **Process**
  - Steering Committee approval of remedial actions
  - Integrated Product Teams notified monthly about their laboratory utilization performance

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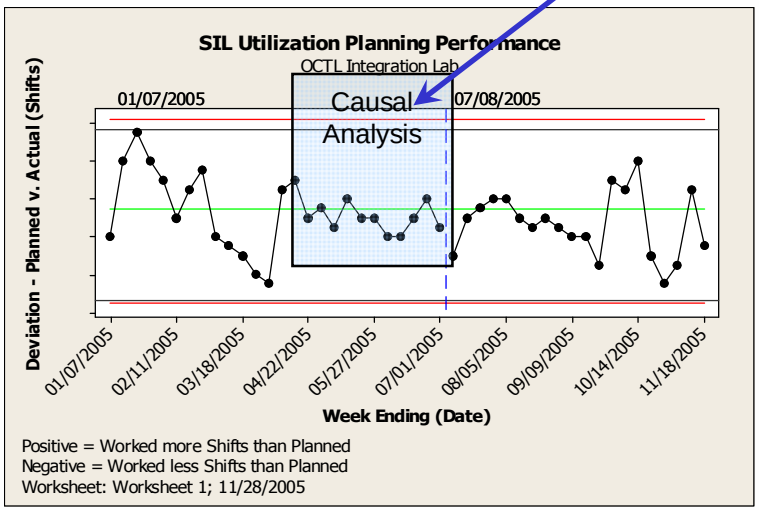
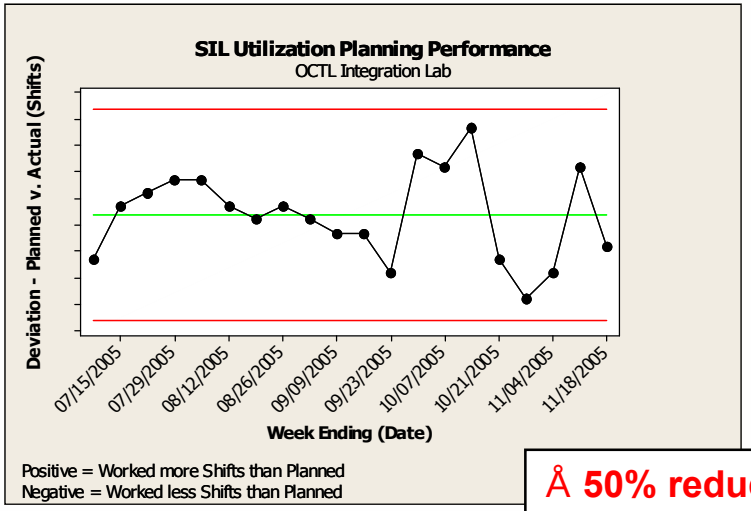
g to an Improved Process

Remedial Actions Implemented 07/08/2005





- **50% reduction in unplanned shifts**
- **18% reduction in variability**

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Cards

- **Flight Test Card Deck Preparation**
  - Time consuming process
  - Incomplete data provided from test plan
  - Too much pulling of info required to build deck
  - Last minute changes disrupt process
  - Development efforts force last minute input
  - Process not well defined or documented
  - Customer perception of *incomplete planning efforts*
  - Customer request for *more time to review* flight cards

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Card Development

Process Title	Flight Test Card Development

Process Definition

Gather flight test requirements, write the Test Point (Test Card) steps, plan and write the mission profile, assemble the deck and receive review approval

Input
- VCRM
- Integrated Test Plan
- Flight (Detailed) Test Plan
- Test Cards *

Sub-Processes Steps
- ÅObtain objectives and requirements
- ÅDevelop test card from approved inputs
- ÅPrepare for and conduct reviews
- ÅCirculate Flight Deck for signature
- ÅConduct Technical Brief and distribute test cards

Output
- ÅAccurate flight deck (mission profile and test cards)
- ÅSufficient Joint Test Force (JTF) review of flight deck prior to flight

Applicable Procedures

ÅTechnical Mission Support ï Flight Card Preparation

Applicable Tools

- Microsoft Word, Archived Test Cards, reviews and meetings

* Test cards are not always provided by the project and are written by the test conductor

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ent Focus

- **Completed brainstorming session for process improvements**
  - Immediate implementation of priority items
- **Process highlights**
  - Documented process with roles and responsibilities
  - Defined input requirements
  - Required test card review prior to submitting deck for approval
- **Early deployment of new Sector test card development procedure**
  - Start date advanced from October to June

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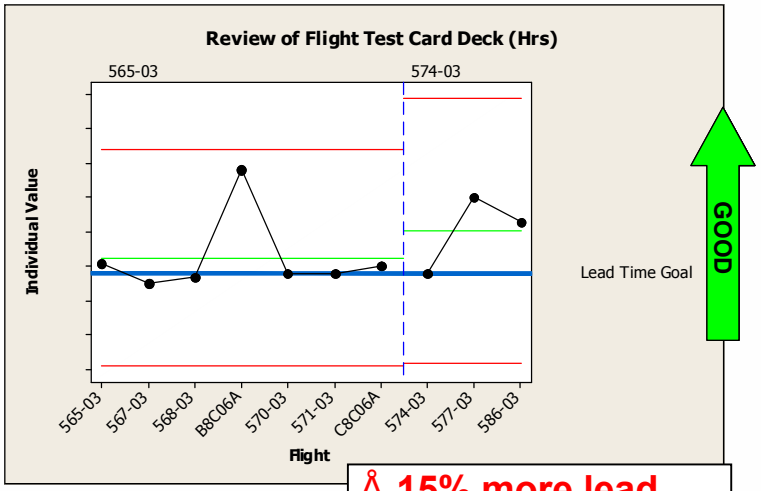
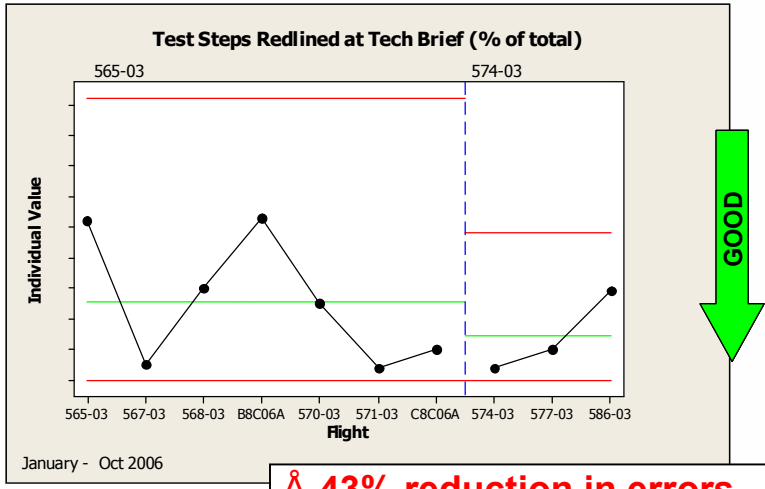
- **Lead Time for Customer Review**



Å 15% more lead time for the review

- **Reduce Redlines at Tech Brief**



Å 43% reduction in errors
Å 47% reduction in variability

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Vehicle Engineering

Drawing Errors

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- **Generation, review & release of engineering drawings is the fundamental business process in Vehicle Engineering**
- **The release process is key to ensuring drawing quality & minimizing future rework**
  - Like peer reviews in the system/software world
- **2006-2007 initiative featured improvements to the release of Direct Drawing Changes**
  - Follow-on to 2005 initiative to improve the release of new drawings
  - Initiatives cover electro-mechanical & vehicle subsystem drawings

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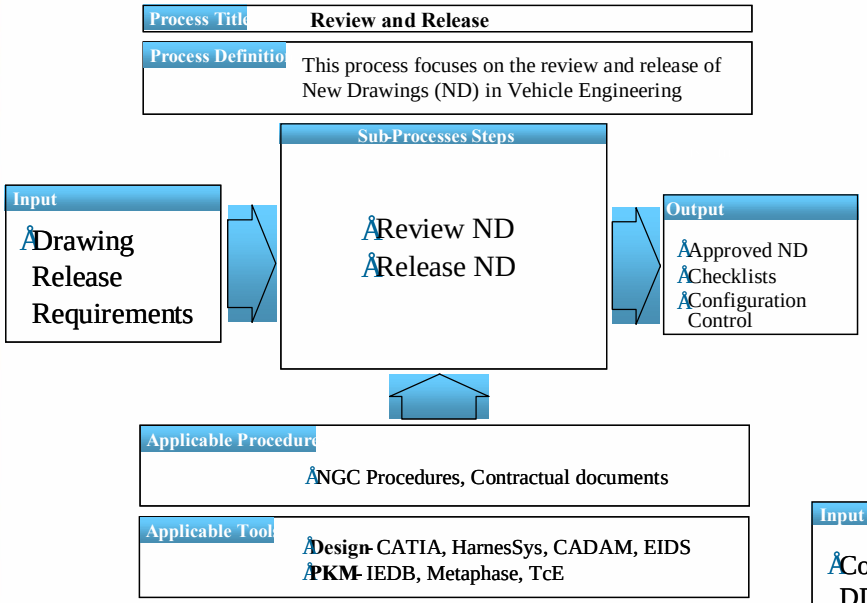
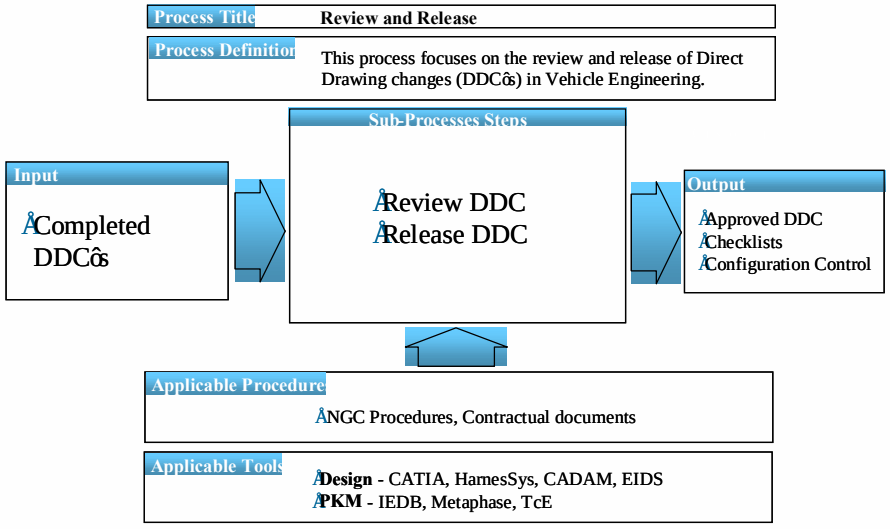
elease

New Drawings (ND)



Direct Drawing Changes (DDC)



Note: A similar process is used for release of Engineering Orders (EOs). Due to the wider variability among EO types/groups, EO baselines are still under development.

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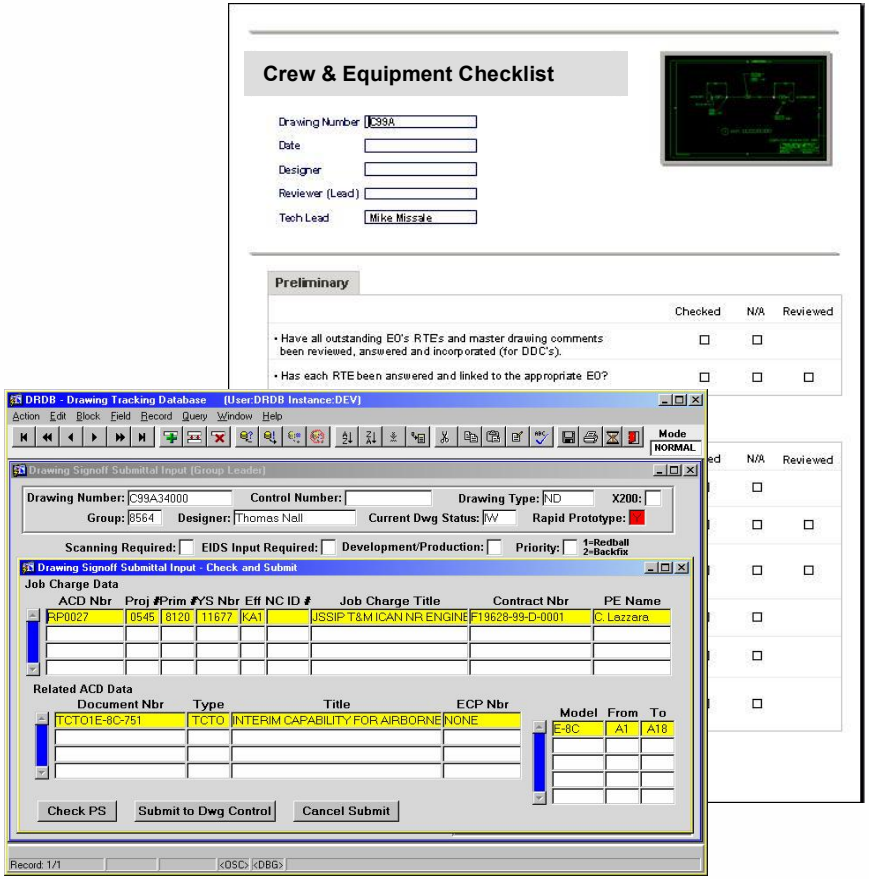
nprovement Focus

- **Created and Utilized DDC Checklists**
- **Leveraged improved engineering database for new DDC data collection**



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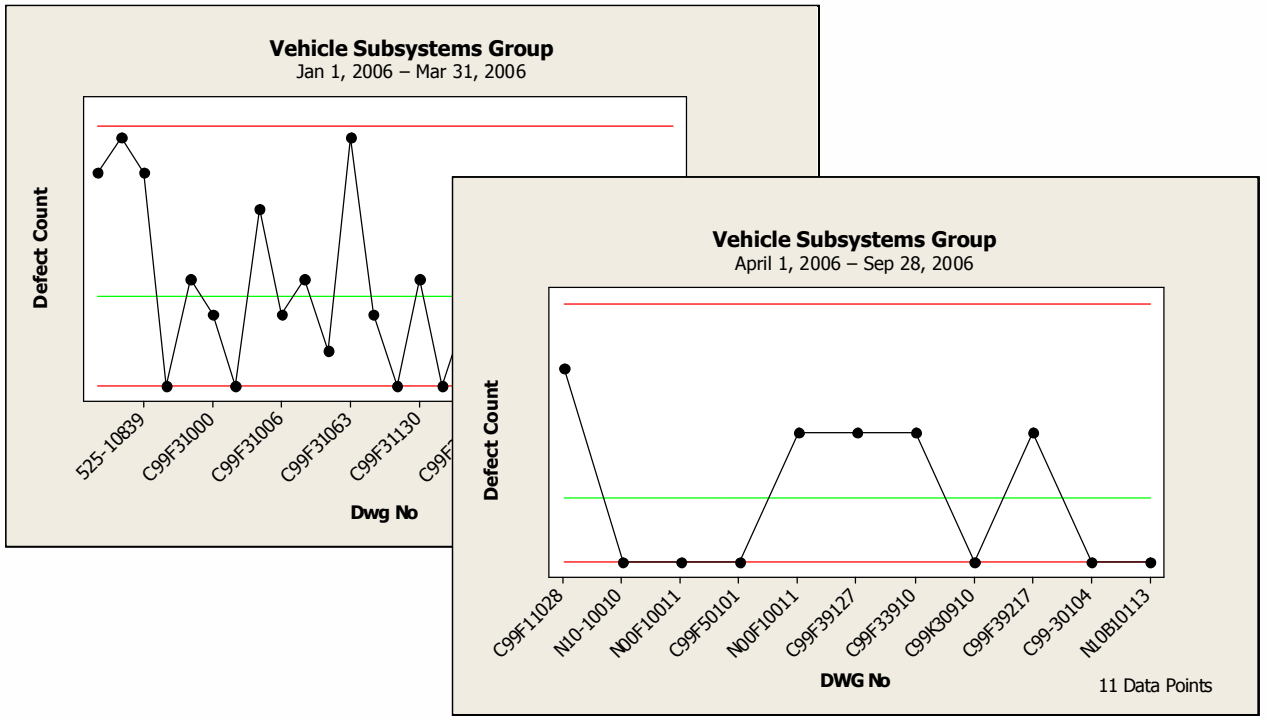

- 61% reduction in drawing errors
- 45% reduction in variability

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Avionics

Discrepancy Inspection Report Processing
Field Service Engineering Request Response

- **In 2005 & 2006, there was a general attempt to baseline and control significant Avionics processes to leverage the benefit of the site's SPC capabilities**
- **Candidates selected based on Pareto analysis**
  - Processing of discrepancy inspection reports (DIRs) for nonconforming items
  - Review of engineering drawings
  - Response to field service engineering requests (FSERs) from field service reps
  - Response to seller issues
- **Process improvement opportunities noted & implemented for DIR processing and FSER response**

First 3 baselines utilize extensions of the author's log-cost model

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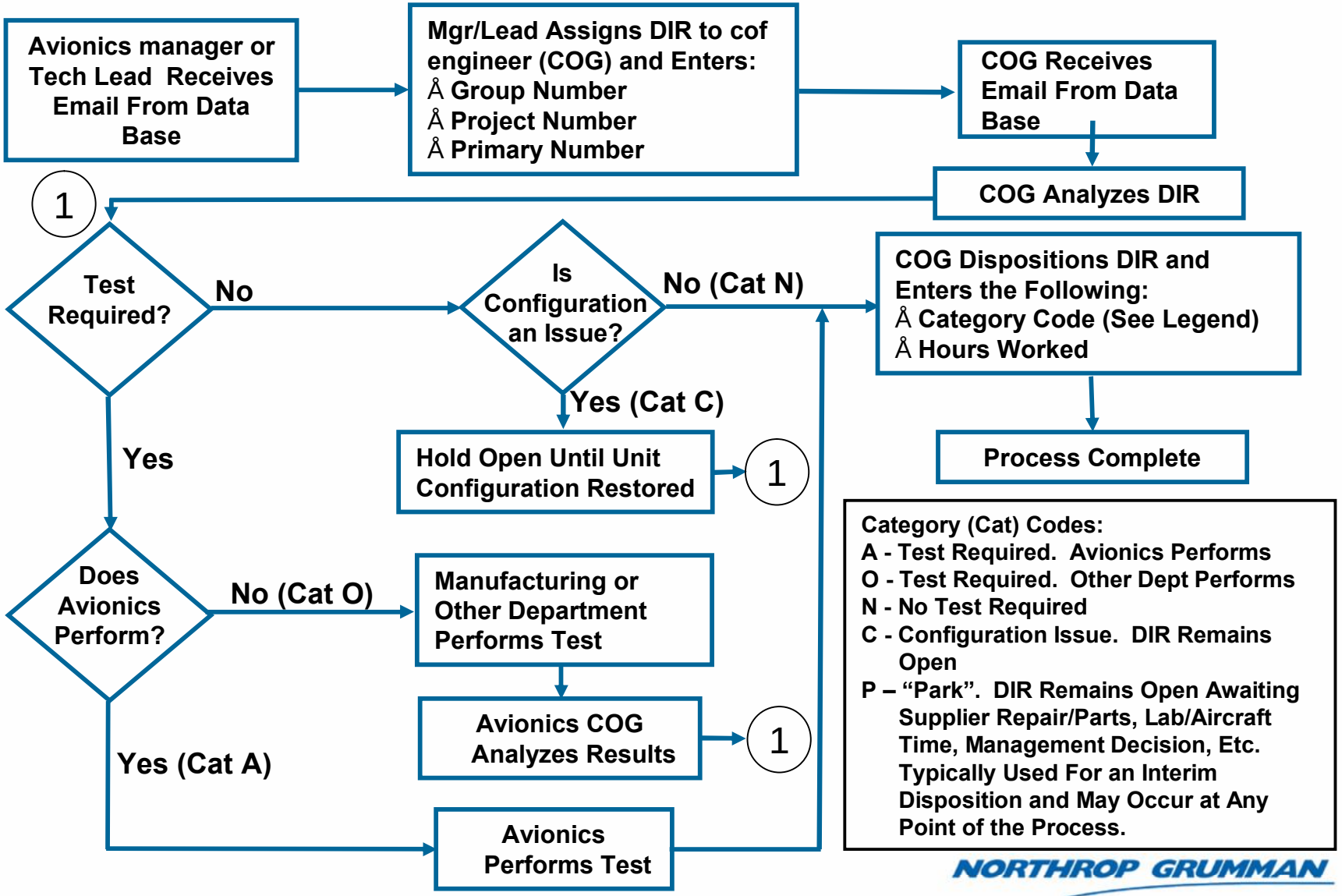
cy Inspection Report (DIR)



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ent Focus

- **Revised existing Avionics work instruction**
- **Optimized Manager/Tech Lead DIR notification and assignment; instituted assignment cross-check to ensure same day assignment**
- **Implemented weekly status reporting & review by Avionics management**
  - Automated management follow-up for DIRs open for 5 days
  - Implemented Category ñPòfor DIRs in work by other groups (Vendor, Lab Ops, etc.)
- **Conducted training**

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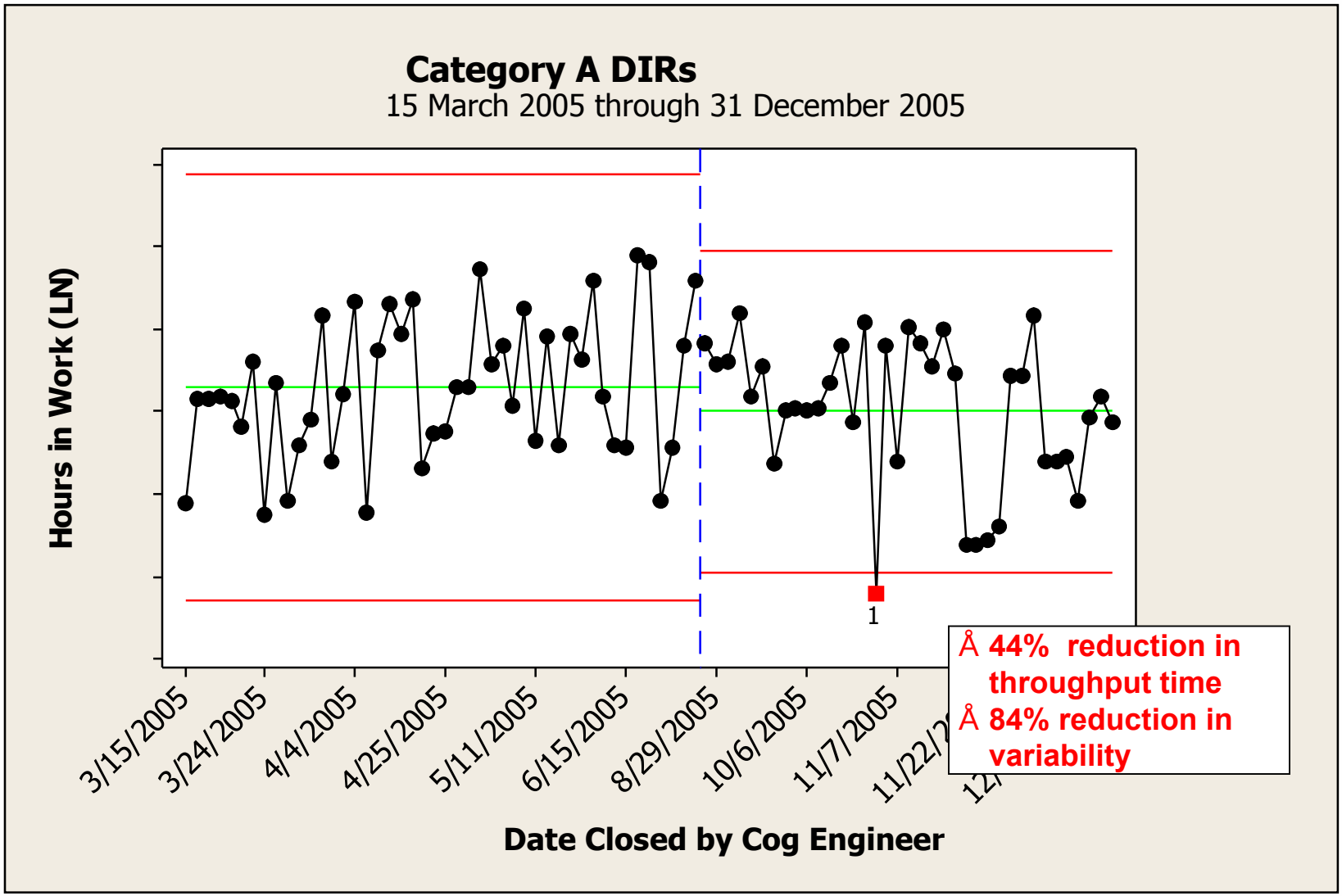

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Process Title Field Service Engineering Request Disposition

Process Owner Avionics Engineering ï Director

Process Definition Process Field Service Engineering Requests (FSERs) routed to Avionics Engineering for review, analysis and disposition.

Supplier

FSER Review Board

Input

FSER Review Board Request

Sub-Processes Steps

- Determine Actionee group within Avionics
- Selects Avionics Engineer as an Actionee
- Notifies FSER Review Board of Avionics Actionee(s)
- The FSER enters ñLevel 5òof FSER tool.
- Conduct kickoff meeting for new FSERs
- Dispositions FSER.
- Update status Weekly
- Generate final response in the FSER Tool
- Review final response

Output

- Dispositioned (Approved or Disapproved) Field Service Engineering Request

Customer

FSER Review Board

Documents/Tools Field Service Engineering Request Tool; Field Service Engineer Request

Metrics FSER Disposition Touch Time; FSER Count; Approval and Disapproval Rates; FSER Review Board (Customer) Feedback

Expected Results FSER that are completely and accurately disposition. Comments that are appropriate, clear, succinct, technically accurate and which meet customer expectations.

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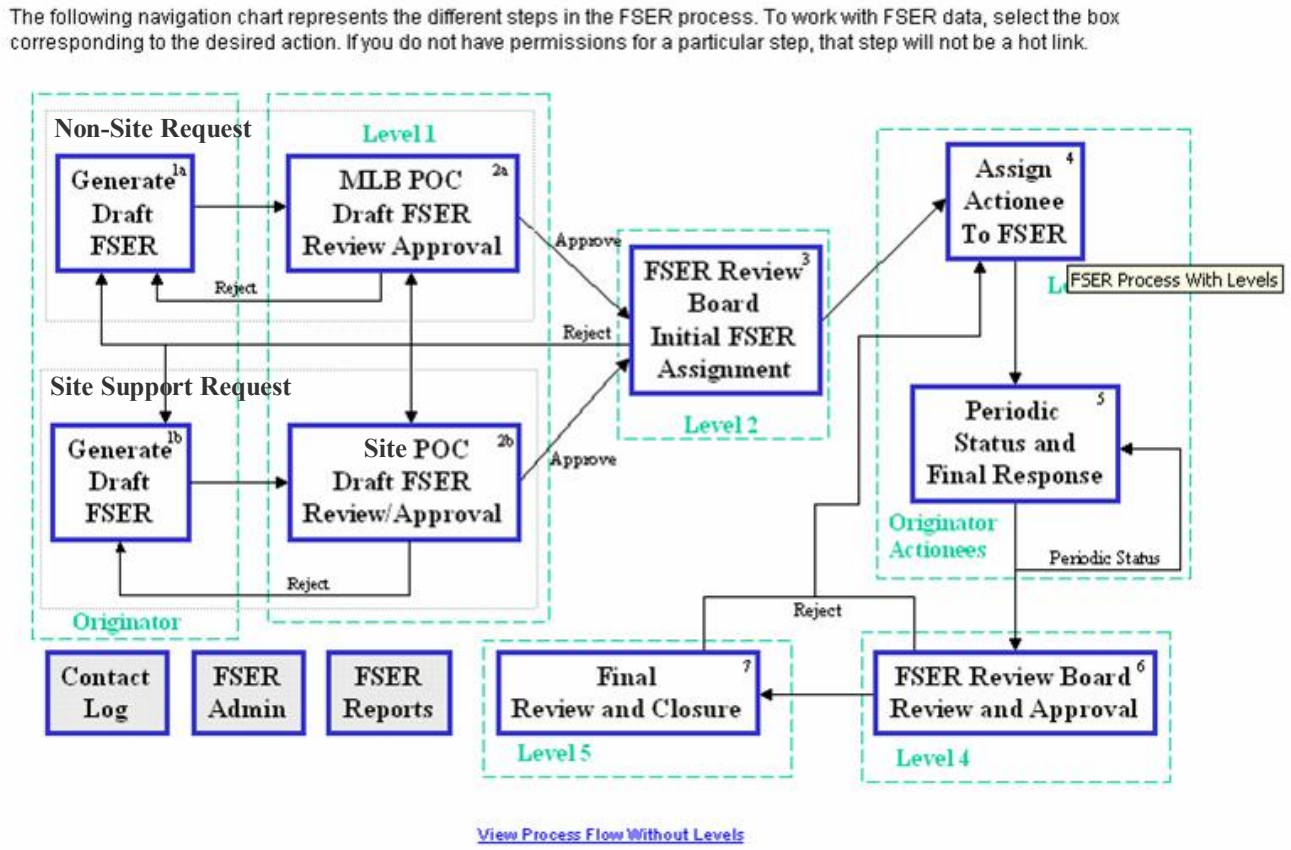
Improvement Focus

- **Issued new Avionics work instruction with automated work assignment, tracking & management follow-up**



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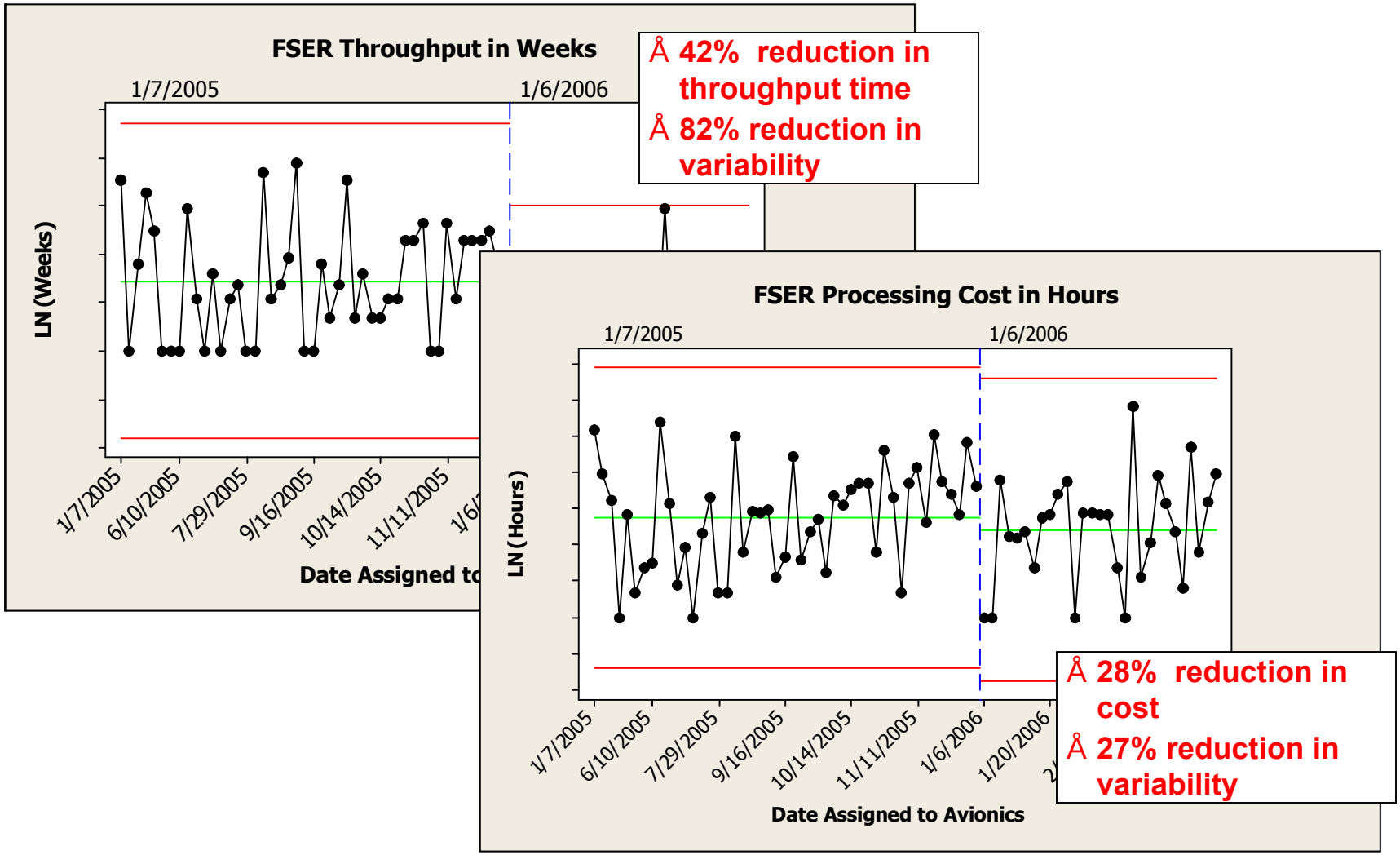

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Logistics

Air Force Tech Order Processing Schedule
Integrated Electronic Technical Manual Delivered Quality

- **In 2004, the Customer requirement to incorporate routine Air Force Technical Orders (AFTO Type 22) into the Joint Integrated Maintenance Information System (JIMIS) was a relaxed schedule**
- **In 2005, Northrop Grumman transitioned to a Total System Support Responsibility (TSSR) sustainment contract**
  - On-time delivery became a component of the TSSR award fee
  - The AFTO 22 delivery requirement was reduced by 57% with the new spec limit

Case study details

AFTO 22 Incorporation

Process Overview

Process Title AFTO Disposition and Incorporation Process

Process Definition Air Force Technical Order (AFTO) Form 22 is the method by which the government recommends changes/ improvements to Technical Manuals. Northrop Grumman dispositions and incorporates the AFTOs issued by the government into Manuals.

Input
- AFTO 22 submitted by JTF
- AFTO 22 Submitted by 116th Wing

Sub-Processes Steps
- NG at Warner Robins dispositions AFTO
- LKS Review & Approval of AFTO
- Processing Days in LKS
- Develop Data Changes in LSA Melbourne
- Incorporate AFTO into JIMIS
- Review Time in Pubs Tech Support
- Gov't Review in Live Feed
- Release of Data
- Data Fielded for use

Output
Tech Orders fielded for usage by the 116th wing

Applicable Procedures
- AFTO Disposition and Incorporation Procedure

Applicable Tools
JIMIS Database, AFTO Database (Access) , Management tracking tool (Excel)

Analysis & Process Improvement Focus

- **In 2004, analysis was conducted on that year's entire data set**
  - Of all data points at or above the new spec limit:
    - 67% resulted from Improvement AFTOs
    - 33% resulted from Correction AFTOs
- **Although not conclusive, preliminary analysis suggested that the two subgroups might have different distributions**
  - This would indicate they should be charted separately
- **Process improvements focused on improving the assignment & management of open AFTO items**

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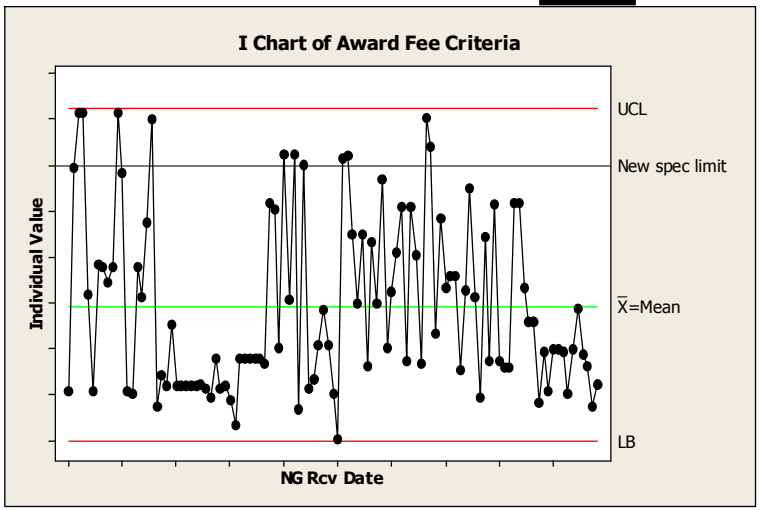
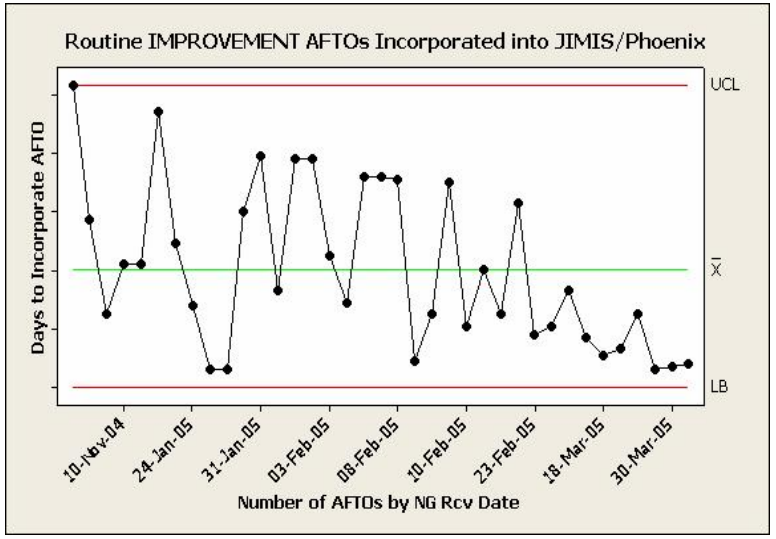
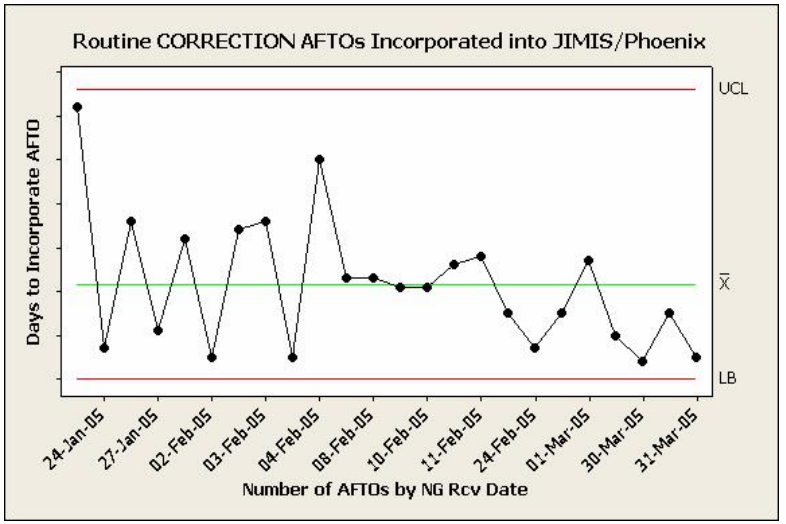
Two Baselines in 2005: Improvement & Correction AFTOs

- 32% reduction in throughput time
- 29% reduction in variability





- 62% reduction in throughput time
- 54% reduction in variability



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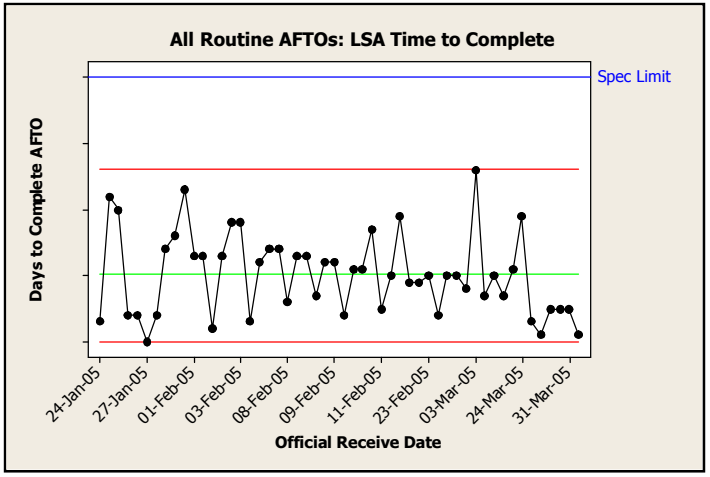
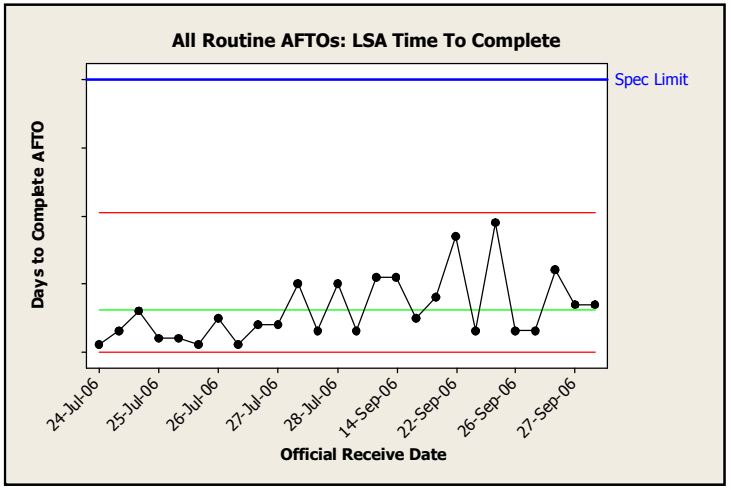
- **2006 process improvement focused on control & optimization of the Logistics Support Analysis (LSA) sub-process within the AFTO 22 process**
- **Similar steps resulted in**
  - 40% reduction in the LSA throughput time
  - 24% reduction in the process variability





t JIMIS

- **JIMIS is a complex, interactive relational database**
  - Integrated electronic technical manual (IETM)
- **Database Size ~ 7.5 GB**
  - > 100,000 pgs of text
  - Replaces ~ 400 technical manuals
- **Used to maintain Joint STARS aircraft**
  - 116th Wing at Warner Robins
- **JIMIS data development – DCMA rated high risk process**
  - Manned aircraft
  - Database changes affect multiple aircraft
  - Errors in maintaining data can have serious consequences on weapon system performance
- **Government reviews new/changed data for quality**
  - ~ 400 submitted in each release cycle (every 75 days)
- **Contract imposes quality performance targets**

Improvement Focus

- **Improved review process**
  - Expanded scope of review
  - Increased standardization of review methods
  - Instituted face-to-face review feedback meetings
  - Synchronized timing of Government review with completion of internal review
- **Better match of reviewers expertise to components reviewed**
- **Automated tracking of review status**

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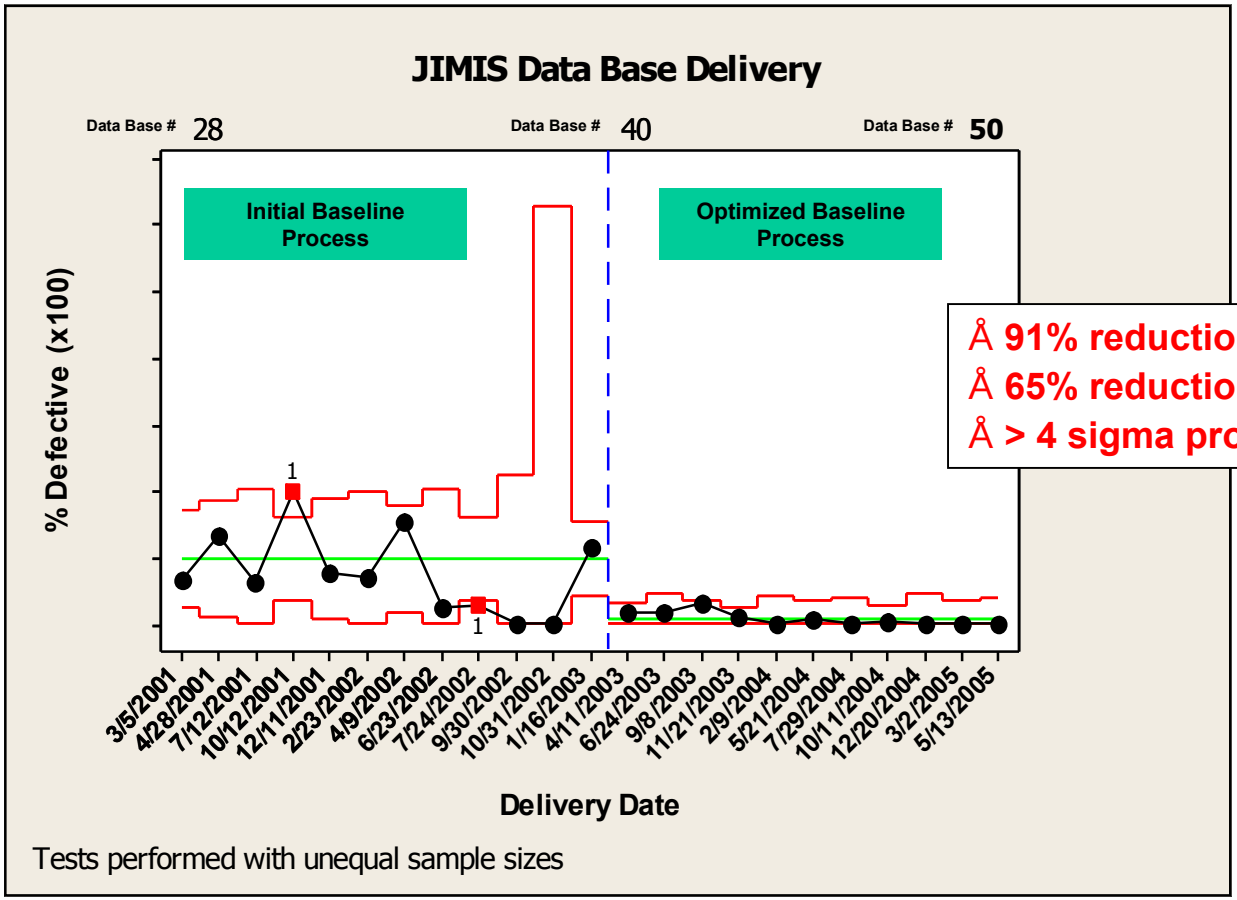

- 91% reduction in errors
- 65% reduction in variability
- > 4 sigma process capability

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- **SPC techniques are broadly applicable in any engineering disciplines**
- **Controlling & improving key business metrics yield measurable benefits**
  - Cost
  - Schedule
  - Quality
- **Simple process improvements work in the real world**
  - Standardization
  - Oversight
  - Automation
  - Training

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